當代決策分析研究智慧結構之探索：作者共引文分析

Exploring the Intellectual Structure of Contemporary Decision Analysis Studies: An Author Co-citation Analysis

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摘　　要

本研究之目的爲探索與討論內含在當代決策分析研究文獻智慧結構之發展。研究方法係採用作者共引文分析和社會網絡分析技術，主要以 2002 年至 2011 年發表在 SSCI 期刊有關決策分析研究議題的研究文獻爲對象，總計分析 205 篇文獻及 7,479 筆參考文獻資料。本研究提出當代決策分析研究領域最具影響力的學者和研究文獻及其之間的相關性；進一步描繪出當代決策分析的知識網絡及闡明其研究領域的發展。研究結果可以讓學術界及實務界更了解決策分析研究之未來發展趨勢。

關鍵詞：決策分析、智慧結構、作者共引文分析、社會網絡分析

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Abstract

The purpose of this study is to explore and discuss the intellectual structure of decision analysis research over the last decade. In this study, author co-citation analysis and social network analysis techniques are used to investigate the intellectual pillars of the decision analysis literature. By analyzing 7,479 citations of 205 articles published in SSCI journals in decision analysis area between 2002 and 2011, this study maps a knowledge network of decision analysis studies. The results help to profile the network of knowledge production in decision analysis and provide important insights with implications for current and future research paradigms of decision analysis studies for management scholars and practitioners.

Keywords: decision analysis, intellectual structure, author co-citation analysis, social network analysis

I. Introduction

Decision analysis is the discipline comprising the philosophy, theory, methodology, and professional practice necessary to address important decisions in a formal manner. Hence, decision analysis can be defined as the application of explicit, quantitative methods to analyze decision under conditions of uncertainty. In the current study, we employ an author co-citation analysis (ACA) to objectively examine the structure of citation relationships among decision analysis studies and to map the decision analysis field with a network approach to explore the importance of authors and to identify other peripheral but influential articles that deserve attention for future exploration. Every discipline is a knowledge system that is a component of a more general knowledge system. Within each discipline, journal articles, books, and monographs play the fundamental role of storing and disseminating information. Of these three means of formal communication (journal articles, books and monographs), journal articles generate the most useful information due to their timeliness and their roles in evaluation and promotion of scholars. Consequently, citations in journal articles in a particular discipline provide an objective measure of the development of that discipline and furnish a relative measure of particular contributions of authors, articles, and journals to the progress of the discipline.

This study uses the ACA and social network analysis to gain an impression of decision analysis research and its evolution from 2002 to 2011 year. Using citation analysis, the interlinked invisible nodes are discovered from which the most influential publications and scholars in the decision analysis field are identified. Further, ACA is conducted to utilize the social network analysis mapping the intellectual structure of decision analysis studies and to explore the invisible knowledge nodes that have contributed most to the studies of decision analysis and their possible evolution patterns.

The paper is divided into four main sections. The first is a review of literature of ACA; the second contains a description of the methodology employed; the third presents and discusses the results of the empirical study; and the fourth section presents a summary and discussion of the conclusions to be draw from this investigation, indicates its limitations, and the future research.

II. Review of the Academic Literature on ACA

Author co-citation analysis (ACA) is a widely applied bibliometric technique that uses a matrix of co-citation frequencies between authors as its input [19] and that has found widespread applicability. ACA, which uses seminal authors in a discipline as the units of analysis, predicates that the conceptual similarity in the works of such authors would increase the likelihood of their being cited together regularly [19]. The frequency of co-citation is therefore a measure of the proximity between authors [29].

ACA's unit of analysis is an individual author rather than a specific paper or journal. It is must be noted that the name of author is merely a label for the central conceptual theme or idea that he or she represents [6][7]. The intellectual map is thus a representation of ideational interactions among authors established through the frequency of co-citation and overall distribution of co-citations that they share with one another [19][30]. This makes ACA eminently suitable for explicating the subfields that fall within the overall disciplinary domain of decision analysis. More specifically, ACA's ability to reveal patterns of association between authors based on their co-citation frequency makes it a prospective methodology for understanding the evolution of an academic discipline [30]. The versatility of the technique and its acceptance by diverse disciplines

make it appropriate for this study.

ACA has proven useful to describe, from an empirical standpoint, the intellectual structure of one academic discipline using an objective method. It has therefore been applied in many academic areas such as management [1], marketing [12], organizational behavior [8], conflict management [17], small enterprise [24], management information systems [6][7][19][29][30][31], strategic management [3][20], international management [2], knowledge management [22], family business [5] and decision analysis [15]. In those disciplines, this methodology contributes to the identification of research gaps and orienting future lines of study. This study also aims to be a quick reference for new researchers to become familiar with the decision analysis field of study.

III. Methodology

In order to provide an overview of contemporary decision analysis research, this study explored the intellectual structure of decision analysis between 2002 and 2011. Citation and author co-citation analysis (ACA) are the main methods for this study. With citation and ACA, this research assumed three stages, each of which required different approaches to examining the evolution of the decision analysis studies.

First, the databases were identified as the sources of decision analysis publications. Then data collection and analysis techniques were designed to collect the desired information about the topics, authors, and journals on decision analysis research. For the data presented here, the Social Science Citation Index (SSCI) was used as parts of the databases. The SSCI was widely used databases, which included citations published in about 2,000 refereed journals. Using SSCI provided the most comprehensive and widely accepted databases of decision analysis publications. Unlike other prior studies in the management field, data used in this study were not drawn from journals chosen by the peer researchers. Instead, the entire databases of SSCI from 2002 to 2011 served as the universe for conducting the analysis.

Decision analysis research field builds its structure on its constituent disciplines. Most of these disciplines, such methods include models for decision-making under conditions of uncertainty or multiple objectives; techniques of risk analysis and risk assessment; experimental and descriptive studies of decision-making behavior; economic analysis of competitive and strategic decisions; techniques for facilitating decision-making by groups; and computer modeling software and expert systems for decision support, as mentioned previously, are well established and have their own publication media. In the scenario marked by an absence of well-established media (a particular journal designated for decision analysis exclusively), the researchers in this field published their work in the publication avenues of their own disciplines, which posed some challenges for this research. Most decision analysis related developments advanced considerably beyond what was drawn from its constituent disciplines, with the integration and coordination of raw materials from other different disciplines for the purposes of application and development. This phenomenon widened the field for search of raw materials in decision analysis and rendered the identification of boundary conditions extremely difficult. To deal with these challenges, this study uses “key words” method which utilizes the SSCI databases key word search in article’s title. Using “decision analysis” as key word, this study included 205 journal articles which cited 7,479 other publications as references. The cited publications in these papers include both published books and other journal articles.

In the second stage, citation analysis was tabulated for each of the 7,479 source documents

using the Excel package. After a series of operations, key nodes in the knowledge network in decision analysis studies were identified and the structures developed. In the final stage, ACA is conducted to utilize the social network analysis and factor analysis which map the intellectual structure of decision analysis studies and to explore the invisible knowledge nodes that have contributed most to the studies of decision analysis and their possible evolutionary patterns.

IV. Results and Discussions

Data mapping was conducted and an intellectual structure of the decision analysis studies was revealed by using ACA. To identify the key publications and scholars that have laid down the groundwork of decision analysis research, citation data were tabulated for each 7,479 source documents using the Excel package. The citation analysis produced some interesting background statistics, as shown in the following tables. Tables 1 list the most cited journals in decision analysis studies in the last decade, among which *European Journal of Operational Research*, *Management Science*, *Journal of Environmental Management*, *Journal of Multi-Criteria Decision Analysis*, and *Medical Decision Making* are the top five, followed by *Forest Ecology and Management*, *Journal of the American Medical Association*, and *Operations Research*. Many of the authors had very few co-citations and were either unlikely to have had a significant impact on the development of the field and/or were too recent to have had time to impact on the literature. The authors selected the 31 most highly cited scholars in the last decade. Table 2 present the results. We employ these scholars as key nodes before conducting social network analysis and factor analysis. In doing so, we were following the procedures recommended by White and Griffith [29].

Table 1 Top 20 Most Cited Journals/Books in Decision Analysis Literature
(Citation Frequency ≧33)

European Journal of Operational Research	314	Risk Analysis	52
Management Science	216	Energy Policy	50
Journal of Environmental Management	101	Ecological Economics	48
Journal of Multi-Criteria Decision Analysis	74	Multiple Criteria Decision	47
Medical Decision Making	71	Analysis Hierarchy Process	41
Forest Ecology and Management	68	Energy	40
Journal of the American Medical Association	57	British Medical Journal	37
Operations Research	56	Decisions with Multiple Objectives	37
Fuzzy Sets and Systems	52	Landscape and Urban Planning	35
Journal of the Operational Research Society	52	Forest Science	33

Table 2 Top Authors Selected for the Co-citation Analysis from 2002 to 2011
(Citation Frequency ≧4)

Keeney RL	52	Zeleny M	10	Harker PT	6	Marttunen M	4
Saaty TL	41	Gregory R	9	Lootsma FA	6	Mustajoki J	4
Belton V	24	Hwang CL	9	Mendoza GA	6	Prato T	4
von Winterfeldt D	22	Poyhonen MA	9	Clemen RT	5	Shannon CE	4
Phillips LD	15	Alho JM	8	von Nitzsch R	5	Stewart TJ	4
Weber M	11	Malczewski J	8	Ananda J	4	Tversky A	4
Edwards W	10	Kangas A	7	Corner JL	4	Yoe C	4
Kangas J	10	Figueira J	6	Dyer JS	4		

Social network analysis tools can be used to graph the relations in the co-citation matrices and identify the strongest links and so the core areas of interest in decision analysis [21]. Figure 1 show the core of the co-citation in this study sample articles with links of greater than or equal to zero co-citation shown in the network. This was produced using UCINET software [4] and shows graphically the core areas of interest. The different shapes of the nodes result from performing a faction study of these authors. This method seeks to group elements in a network based on the sharing of common links to each other. These factions can be interpreted as concentrating on the interaction between multiple criteria decision analysis, multi-criteria analysis, multi-criteria decision-making, analytic hierarchy process, and outranking methods.

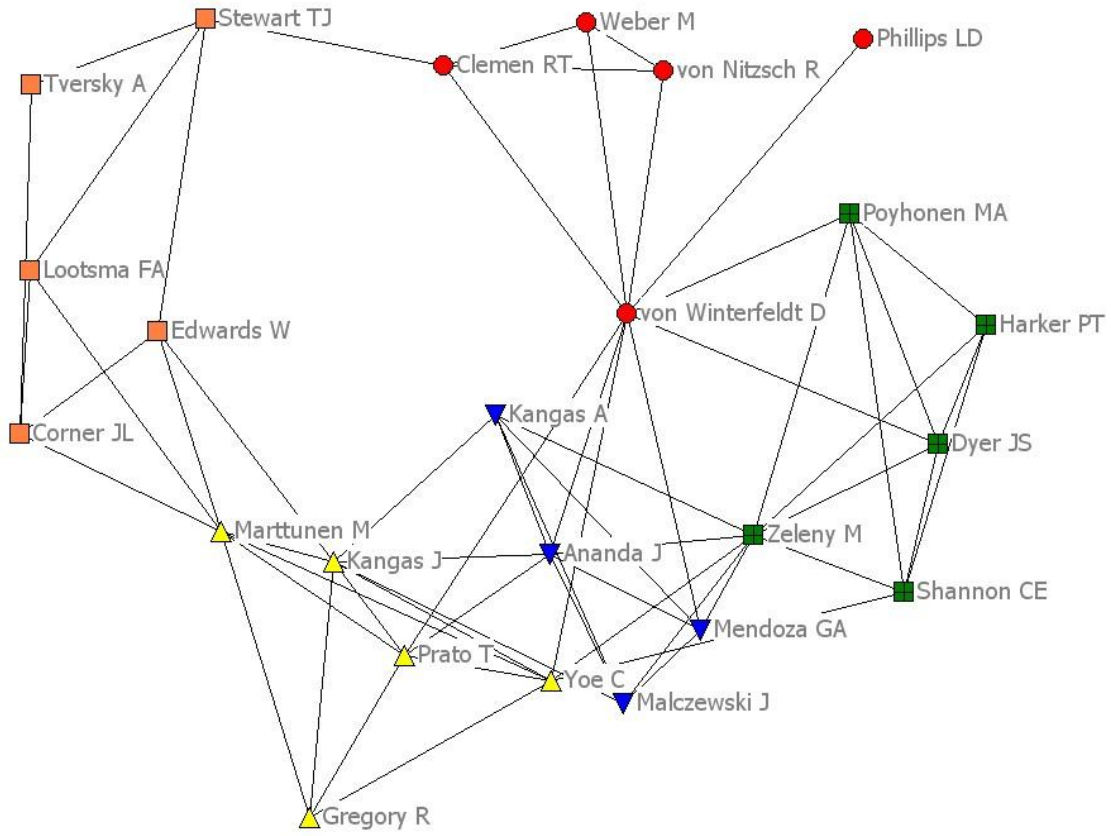

Figure 1 Core Areas Co-citation Network Map: 2002-2011

Whilst the diagram in Figure 1 is very telling and provide a clear picture, its focus is only on the very core area and a limited amount of the data available. By taking the co-citation matrix and grouping the authors using factor analysis of the correlation between the entries determines which authors are grouped together and there for share a common element. According to this, the closeness of author points on such maps is algorithmically related to their similarity as perceived by citers. We use r-Pearson as a measure of similarity between author pairs, because it registers the likeness in shape of their co-citation count profiles over all other authors in the set [30]. The co-citation correlation matrix was factor analyzed using varimax rotation, a commonly used procedure, which attempts to fit (or load) the maximum number of authors on the minimum number of factors. The diagonals were considered it missing data and apply the criterion of omitting the two cases (pairwise delete) [19].

Following the example of previous studies [2][6][29], the authors considered that a work should be included in a particular research trend when its loading is equal to or greater than 0.4, and if the loading is greater than 0.7, the work is a contribution of great relevance within the corresponding paradigm. The results of the factor analyses, five factors were extracted for the last decade. Tables 3 show the results of this analysis. Significantly, most of the authors' works are loaded with a weight greater than 0.7, corroborating the relevance of these works within their respective paradigms. These works are of even greater interest, as they represent bridges between paradigms and allow us to observe a broader spectrum of influences among those works that belong to different research fronts, helping us to understand their evolution and the links that have been forming between the different research trends.

Five factors were extracted from the data and together they explain over 79.2% of the variance in the correlation matrix of the last decade. Table 3 lists the five most important factors along with the authors that had a factor loading of at least 0.5. As is usual in this type of analysis, authors with less than a 0.4 loading were dropped from the final results [29]. We tentatively assigned names to the factors on the basis of our own interpretation of the authors with high associated loadings. Implicitly, our interpretation of the analysis results is that the decision analysis field is composed of at least five different sub-fields: multiple criteria decision analysis, multi-criteria analysis, multi-criteria decision-making, analytic hierarchy process, and outranking methods. No attempts were made to interpret the remaining factors on account of their relatively small eigenvalues (>1), and thus they have been excluded from Table 3.

Table 3 Top Authors' Factor Loadings at 0.50 or Higher: 2002-2011

Factor 1: MCDA		Factor 2: MCA		Factor 3: MCDM	
von Nitzsch R	0.95	Tversky A	0.94	Gregory R	0.95
Weber M	0.94	Lootsma FA	0.93	Prato T	0.92
Clemen RT	0.83	Corner JL	0.91	Yoe C	0.86
Phillips LD	0.79	Edwards W	0.85	Kangas J	0.86
von Winterfeldt D	0.75	Stewart TJ	0.85	Marttunen M	0.81
Mustajoki J	0.66	Keeney RL	0.68		
Belton V	0.60				
Eigenvalues	9.75		5.00		4.19
% Variance	31		15.9		13.3
Factor 4: AHP		Factor 5: Outranking Methods			
Shannon CE	0.95	Kangas A	0.93		
Harker PT	0.95	Malczewski J	0.91		
Dyer JS	0.91	Ananda J	0.88		
Poyhonen MA	0.90	Mendoza GA	0.76		
Zeleny M	0.82				
Hwang CL	0.55				
Eigenvalues	3.14		2.81		
% Variance	10.0		8.9		

In the last decade, we extract the following findings from Table 3 and Figure 1. The first factor is related to the study of Multiple Criteria Decision Analysis (MCDA), also called multi-attribute value theory (MAVT), provides useful methods for environmental decision making. Von Nitzsch and Weber [27] developed a Range Sensitivity Index (RSI) to measure the empirically observed adjustment of weights relative to the adjustment prescribed by the normative model. They found that the empirically observed adjustments were typically half those mandated by the model. Weber and Borcherding [28] reviewed the previous work of Von Nitzsch and Weber [27] concluded that in each study decision makers do not take range adequately into account when adjusting weights. These results from descriptive research are of importance for the prescriptive use of decision analysis.

The second factor is related to the study of Multi-criteria Analysis (MCA). Tversky and Kahneman [26] explored the systematic biases accruing from judgements and choices based on intuitive errors which stem from a number of fallacies and mis-computations inherent in human information processing. Their experimental results were revolutionized research on judgement and decision making, and their influence quickly spread beyond psychology into fields as diverse as medicine, politics, law, economics and business administration. Moreover, MCA is a framework for combining multiple environmental, social, and economic objectives in policy decisions. Lootsma et al. [16] used scenarios and MCA to devise a long-term strategy for electricity supply. They used a pair-wise comparison to evaluate nuclear, coal and gas-based strategies to satisfy the national electricity demand

within the context of a low, medium, and high scenario for the growth of the national economy [16].

The third factor is related to the study of Multi-criteria Decision-making (MCDM). Gregory, McDaniels, and Fields [10] make reference to Keeney's [14] theory of 'value-focused thinking', which suggests that consideration of values precedes that of available alternatives when individuals make decisions. Gregory et al.'s studies have indicated that stakeholder values are the key to structured policy making with public involvement. In general, MCDM methods have been applied to valuations of water quality, water supply, and river management [23], among many other environmental, natural resources, and other types of problems. MCDM can help ensure that the decision process is balanced and systematic so that restoration decisions are more likely to reflect the stakeholders' values.

The fourth factor is related to the study of Analytic Hierarchy Process (AHP). Shannon's mutual information measurement algorithm [25] has used to compute the information about a set of stimuli conveyed by the responses of a set of neurons. Generally, information is defined as a reduction in uncertainty, thus the quantity called mutual information [25]. There has been some criticism of the AHP in the operations research literature. Harker and Vargas [11] showed that AHP does have an axiomatic foundation, the cardinal measurement of preferences is fully represented by the eigenvector method, and the principles of hierarchical composition and rank reversal are valid. On the other hand, Dyer [9] has questioned the theoretical basis underlying AHP and argues that it can lead to preference reversals based on the alternative set being analyzed.

The finally factor is related to the study of outranking methods. Kangas et al. [13] used the outranking methods as tools in strategic natural resources planning, in order to compare three multi-criteria techniques: MAUT, ELECTRE and PROMETHEE. It should be noted that the final ranking of strategies is highly sensitive to the technique used. An important advantage of outranking methods, when compared to decision support techniques most often applied in today's natural resources management, is the ability to deal with ordinal and more or less descriptive information on the alternative plans to be evaluated [13]. Outranking methods represent the European school, or more specifically, the French school of thought among multiple criteria decision support (MCDS) approaches. Applications of MCDS methods of varying characteristics can be found in the management planning of multiple-purpose forestry. Furthermore, AHP is a multi-objective, multi-criteria decision-making approach that employs a pair-wise comparison procedure to arrive at a scale of preference among a set of alternatives [18].

V. Conclusions

This paper has investigated decision analysis research using citation and co-citation data published in SSCI between 2002 and 2011. A factor analysis of the co-citations suggested that the field is organized five different concentrations of interest of the last decade: multiple criteria decision analysis, multi-criteria analysis, multi-criteria decision-making, analytic hierarchy process, and outranking methods. These results help to profile the invisible network of knowledge production in decision analysis and provide important insights with implications for current and future research paradigms of decision analysis studies for both management scholars and practitioners.

In this paper, the authors present the most influential scholars and identify the linkage among different scholars and confirm the status of each scholar in their contribution to the decision analysis field. The authors have profiled the major themes,

concepts and relationships which discussed within each domain. The authors also found that the scope of decision analysis research has been broad and there are many research opportunities emerging in the coming evolution of decision analysis. The contribution of this paper is to provide a valuable research direction in the decision analysis area and propose an objective and systematic mean of determining the relative importance of different knowledge nodes in the development of the decision analysis field.

In our study, we only reviewed briefly decision analysis studies that appeared on our top authors list of the last decade. Due to the limitation of our database (we only used SSCI); the results of our study should be taken cautiously. Moreover, due to the time lag, many recent articles did not show highly cited in our co-citation network. Our study offers more of a historical review of the development of decision analysis field, rather than judging the importance of different authors or articles. The omission of the recent works is not due to their lack of importance, but purely our methodological limitations. As discussed above, future study is encouraged to combine the method of author co-citation analysis with content analysis. With a methodology combining both author co-citation analysis and content analysis, the future study will present the more comprehensive research evolution in the decision analysis field.

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